THE ORBITAL MOTION IN LEO REGION: CBERS SATELLITES AND SPACE DEBRIS

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ABSTRACT

The objects orbiting the Earth are classified, basically, in Low Earth Orbit (LEO), Medium Earth Orbit (MEO) and Geostationary Orbit (GEO). Most of the objects are found in the LEO region because this region has a big quantity of space debris. Considering approximately 10000 cataloged objects around the Earth, one can verify the distribution of objects as: 27 % of operational spacecraft, 22 % of old spacecraft, 41 % of miscellaneous fragments, 17 % of rocket bodies and about 13 % of mission-related objects. The uncatalogued objects larger than 1 cm are estimated in some value between 50000 and 600000.

Currently, the orbital motions of the cataloged objects can be analyzed using the 2-line element set of the NORAD (North American Defense). The TLE are composed by seven parameters and epoch. These data can be compared, for example, with the model of the orbit propagator situated in the artificial satellite. A similar study is done for the Brazilian satellite CBERS-1 in cooperation with China. In this case, orbital perturbations due to geopotential, atmospheric drag, solar radiation pressure, gravitational effects of the Sun and the Moon are considered in the numerical integration of the orbit and the results are compared with the TLE data.

The present distribution of objects by the value of the mean motion n indicates the commensurability between the frequencies of the mean motion of the object and the Earth's rotation motion. It is verified that most of objects are in the region $13 \leq n(rev/day) \leq 15$.

The space between the Earth and the Moon has several artificial satellites and distinct objects in some resonance. Synchronous satellites in circular or elliptical orbits have been extensively studied in literature, due to the study of resonant orbits characterizing the dynamics of these satellites.

In this work, resonant orbital motions of the CBERS (China-Brazil Earth Resource Satellite) satellites are studied using the TLE files of the NORAD.

If the commensurability between the orbital motion of the object and the Planet is defined by the parameter α and by the condition $\alpha = (k+q)/m$, one can say that the exact 14:1 resonance is defined by the condition $\alpha = 1/14$. Analyzing the motions of artificial satellites CBERS-1 and CBERS-2, one can observe resonant angles in the neighborhood of the exact 14:1 resonance.

The orbital motions of the CBERS satellites can be corrected during your lifetime, because some disturbances, resonance effects or collision risk can affect your mission. These corrections can be seen by the abrupt change in the values of the semi-major axis. In this way, the study of the resonant

angles using real data of the artificial satellites is limited to the period without corrections. However, the study involving space debris allows to use a long time and consequently a better analysis about the resonant period in a given region.

The results and discussions show the complexity, in the orbital dynamics of these objects, caused by the resonance effects. Figures show time behavior of the semimajor axis, eccentricity, resonant angles and resonant periods.

Energy's curves are observed in the (ω, e) plane of the orbital motions of CBERS-1, CBERS-2 and CBERS-2B satellites indicating the presence of Kozai's resonance in their orbits. Where ω is the argument of pericentre and e is the eccentricity.

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